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STRUCTURAL AND ELECTRICAL PROPERTIES OF TUNGSTEN - TITANIUM SPUTTERED COATINGS

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Abstract

Correlation of structural and electrical properties of W-Ti thin films deposited by sputtered were studies. The results have shown that changes of grain size are in agreement with the sheet resistance behavior as a function of the thin films thickness. The characteristic change of grain size and sheet resistance are obtained in thickness interval between 100 – 150 nm

Introduction

Thin films and coatings of the system W-Ti have been developed as an alternative to titanium – based coatings, which are considered for applications as protective coatings. Beside very high hardness and adhesion, these thin films/coatings should be thermally stable and oxidation resistant[1]. Thin films of tungsten with specific properties, can be used in very important fields: protective materials[2], microelecronic and gas sensors [3].

For deposition coatings, the sputtering method is especially interesting because the composition and the properties of thin films can be controlled by sputtering conditions. In this work, we have studied structural and electrical properties of sputtering deposited thin films of alloy. These features of deposits have been observed as a function of the deposits thicknesses.

Experimental

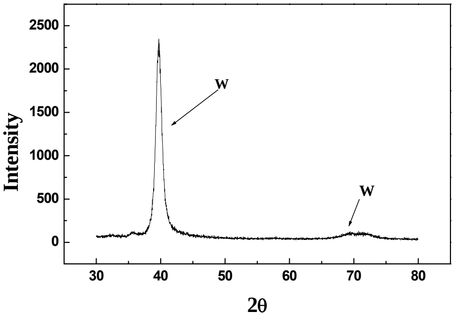
The thin films have been deposited by d.c. sputtering of a tungsten – titanium (90%W – 10%Ti w.t.) alloy target by Ar^+ ions. Acceleration voltage (U = 1.5 kV) and current on target (I = 0.7 A) were maintained constant during the deposition. The base pressure in the chamber was $p = 1 \cdot 10^{-3}$ Pa and the partial pressure of argon in the chamber was $p_{Ar} = 1 \cdot 10^{-1}$ Pa.

The phase composition and crystalline structure of W-Ti deposits were deterninated by x-ray diffraction method (Cu Kα emission). Angles 2θ, in the range from 30° to 80°. The crystalline size was determinated by FWHM from corresponding peak and for crystalline spheric sharpe [4].

The sheet resistance of the deposited W-Ti thin films onto the silicon substrate was determinated by the standard four-point probe method.

Results and Discussion

The thin films of W-Ti alloy were deposited on single crystal silicon orientation (100). The x-ray diffractograms of the as – deposited layer, thickness d = 900 nm is presented in Fig. 1a and it has shown only diffraction lines, which corresponded to the bcc α - tungsten phase. The diffractograms of W-Ti thin films showed the (110) preferred growth orientation, although the presence of (211) diffraction line was also detected.



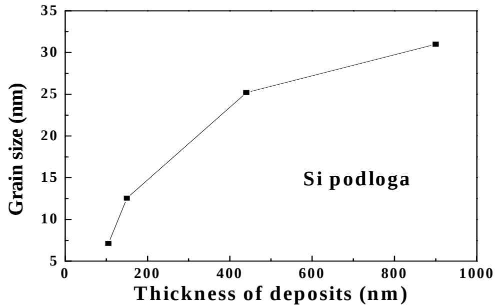


Fig. 1. Structural propertise of W-Ti deposits on Si:a) XRD diffractograms and b) the grain size in a function of thickness of deposits.

The value of lattice parameters of the W-Ti layer for thickness of d = 900 nm a = 0.3223 nm. In comparison obtained values for the lattice parameters with a value of α - tungsten which amounted a = 0.3165 nm, the addition of the titanium to the W alloy, resulted in an expanded α - tungsten lattice.

The grain size have shown growth with increase of the thickness of W-Ti films on Si substrate, as presented in Fig. 1b. In chosen interval thickness, the grain size increases and reash vlues about 31nm. The obtained values of grain size characterize the preferential growth of the crystallites in the layer plane.

Electrical properties of deposited W-Ti are determinate with sheet resistance and resistivity, which are presented on diagrams on Fig. 2(a and b). The sheet resistance of W-Ti films as a function of film thickness, in range 10 to 900 nm is presented in Fig. 2a. The values of sheet resistance were high for a low thickness and amounted about 80 Ω/sq. By further increase of the thickness deposit, the sheet resistance decreases and at above 400 nm, approaches value for bulk material. The conduction mechanism of the deposits change also, from thermally activated tunneling for low thickness to metallic conduction when the deposit thickness increases [5].

The W-Ti film resistivity as a function of film thickness in a range from 10 to 900 nm, is presented in Fig. 2b. The results have shown that for thickness smaller than 400 nm, the resistivity depends on film thickness. For W-Ti deposits, thickness greater than 400 nm, resistivity has a value of 119 μΩm. In small thickness region, significant maximum of resistivity at 100 nm appeared. The obtained results are in agreement with the grain size behavior as a function of the film thickness (Fig 1b). For thickness of 100 nm rapid increase of the grain size is obtained. He obtained resistivity value at used experimental conditions is higher than the bulk resistivity of tungsten, as a consequence of electron scattering at alloying elements – titanium.

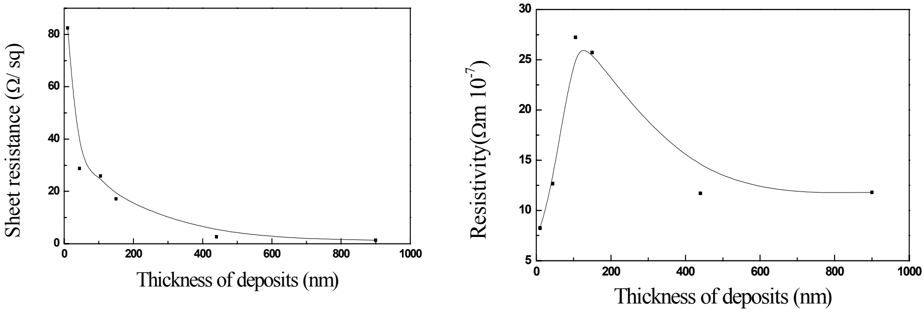


Figure 2. Electrical properties of W-Ti deposits on silicon substrate as: a) sheet resistance and b) resistivity as a function of thickness deposits

Conclusion

The properties of W-Ti thin films deposited by sputtering onto silicon are presented. At chosen experimental conditions, W-Ti deposits had a fine grain structure at the same time as crystal structure of W-Ti deposits corresponded to structure of α - tungsten with bcc lattice. The presence of titanium lead to extended crystal lattice of α - tungsten.

The electrical properties are thickness dependent. By increasing the thickness the sheet resistance rapidly decreases reaching constant value of 2Ω/sq at the thickness 400 nm and higher. High resistivity of W/Ti deposits from 119 μΩm, are consequence electron scattering at alloying elements and other factors.

References

[1] T. Nenadović, Material Science Forum 1996, 214, 163
[2] C. Louro and A. Cavaleiro, J. Electrochem. Soc., 1997, 144(1), 259.
[3] J. M. Oparowski, R. D. Sisson, Thin Solid Films, 1987, 153, 313.
[4] B.D. Cullity, Elements of X-ray Diffraction, 2^{nd} ed. Addison-Wesley, Ma, 1978.
[5] I.M. Rycroft, B.L. Evans, Thin Solid Films 1996, 290-291, 283